(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU [illegible]126622 B2
(10) Patent No. 769556

(54) Title
Sensor system for detecting an angle of rotation and/or a torque

(51)6 International Patent Classification(s)
G01L 003/00

(21) Application No: 200126622 (22) Application Date: 2000.11.22

(87) WIPO No: W001/40750

(30) Priority Data

(31) Number	(32) Date	(33) Country
19958504	1999.12.04	DE

(43) Publication Date : 2001.06.12
(43) Publication Journal Date : 2001.08.23
(44) Accepted Journal Date : 2004.01.29

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(56) Related Art
US 5501110
US 4972725

AU 200126622

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

(43) Internationales Veröffentlichungsdatum
7. Juni 2001 (07.06.2001)

PCT

(10) Internationale Veröffentlichungsnummer
WO 01/40750 A3

(51) Internationale Patentklassifikation[7]: G01L 5/22, 3/10

(21) Internationales Aktenzeichen: PCT/DE00/04117

(22) Internationales Anmeldedatum: 22. November 2000 (22.11.2000)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
199 58 504.0 4. Dezember 1999 (04.12.1999) DE

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(81) Bestimmungsstaaten (*national*): AU, BR, CN, JP, US.

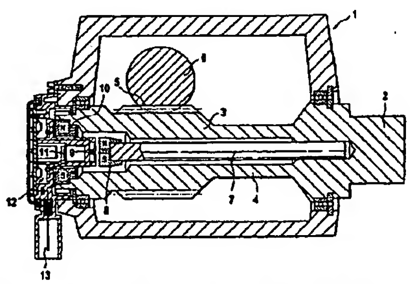
(84) Bestimmungsstaaten (*regional*): europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Veröffentlicht:
— *mit internationalem Recherchenbericht*

[Fortsetzung auf der nächsten Seite]

(54) Title: SENSOR SYSTEM FOR DETECTING AN ANGLE OF ROTATION AND/OR A TORQUE

(54) Bezeichnung: SENSORANORDNUNG ZUR ERFASSUNG EINES DREHWINKELS UND/ODER EINES DREHMOMENTS



(57) Abstract: The invention relates to a sensor system for detecting the angle of rotation and/or the torque of rotating mechanical components (1). The rotating component comprises a torsion shaft which is configured as an external shaft (3). A torque is applied to one region (2) at the end of said shaft and can be removed in the region (5) at the opposite front end of the shaft. An internal shaft (7) is positioned concentrically in relation to the external shaft (3) and one end of the internal shaft is connected to the external shaft (3) in the region (2) of the entry point of the torque. The front end of the external shaft (3) and the internal shaft (7) are preferably provided with magnets (8, 10) with magnetic fields which lie in a radial direction in relation to the shaft axis, to which a respective fixed sensor is allocated. The relative torsion of the magnetic fields in relation to each other can be measured under the effects of the torque, the angle of torsion being proportional to the torque angle.

(57) Zusammenfassung: Es wird eine Sensoranordnung zur Erfassung des Drehwinkels- und/oder des Drehmoments an rotierenden mechanischen Bauteilen (1) vorgeschlagen, bei der am rotierenden Bauteil eine Torsionswelle als Aussenwelle (3) gebildet ist, an dessen Bereich (2) an einem Ende ein Drehmoment angreift und im Bereich

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Sensor arrangement for detecting an angle of rotation and/or torque

Prior Art

The invention relates to a sensor arrangement for detecting an angle of rotation and/or torque, in particular on axles or shafts, according to the preamble of the main claim.

A sensor arrangement is already known from US-PS 5,510,110 in which the torque transferred to an axle is to be detected. The torque is determined from the torsional offset or the rotational angle offset of the axle ends and an elastic constant, which depends on the material and the geometry of the axle. Here two magnets and one Hall sensor adjacent to the magnets respectively, are fixed eccentrically on the external periphery of two discs each rotating with the axle.

For example for detecting the torque acting on a steering wheel axle of a vehicle during the turning of the steering wheel, very small angle changes must be measured in both rotational directions of the steering wheel. The torque in the rotating steering column is a key factor for many regulating and control tasks in the vehicle and can be detected in principle for known types viewed separately. For example this can also be constructed with a sensor arrangement according to the Foucault principle or with an optical arrangement consisting of a encoder disc and a CCD-chip.

In sensor arrangements according to the principle known from prior art and named above, the danger exists, that by means of a rotational modulation which come about due to tolerance problems in the arrangement of the poles of the magnets, relatively large measurement errors can occur. Moreover, signal transmission can also be difficult in signal detection in rotating waves, which can be loosened after use with a variable transformer or with slip rings, but is cost intensive and susceptible to faults.

<u>Advantages of the invention</u>

The generic sensor arrangement mentioned in the preamble for detecting the rotational angle and/or the torque on rotating mechanical components is further developed advantageously according to Claim 1 in that a torsion shaft is constructed as the external shaft on the end of which torque acts. The torque can then be removed at the opposite front end of the external shaft, an internal shaft lying concentric to the external shaft, and is connected at one end to the external shaft in the area of the entry shaft in the area of the entry point of the torque. On the front end of the external shaft and the internal shaft are, according to the invention, signal generating elements to which a fixed detection element is allocated.

In a preferred embodiment a magnet is arranged as a signal generating element to the internal shaft for detecting the angle of rotation on the torque entry point and generates a radial magnetic field, which lies in a radial direction with relation to the shaft axis. A further magnet as a signal-generating element on the external shaft is arranged advantageously concentrically to the internal shaft outside the one magnet for detecting the angle of rotation of the exit point. By this means a further radial magnetic field is generated, so that now, by means of the effect of the angle of rotation the torsion of the magnetic fields can be measured relative to one another, the angle of torsion being proportional to the torque.

The detection elements or sensors can simply be magnetoresistive sensors, for example so-called AMR or GMR sensors (AMR = anisotropic magnetoresistive, GMR = giant magnetoresistive), which emit an independent signal largely from the field line direction of magnets connected to the rotatable shafts and is so arranged in the magnetic field of the magnets, that their magnetic field sensitive layer lies tangential to the rotating of the shafts causing the change of angle.

In an advantageous evaluation circuit, from these signals the absolute rotational angle of the internal and external shaft and, as mentioned above, from the relative angle of torsion the influencing torque can be determined. An especially advantageous

application of the invention results when the internal and the external shaft are applied to the steering column of a vehicle.

It is also advantageous if, on the front end of the external shaft, a drive for a further rotating component is applied eccentrically or concentrically to the shaft axis. By this means rotations of the external shaft or of the steering column greater than 360° can be detected and evaluated, the detection of the rotation of the further body also with a magnetic field sensitive sensor arrangement can be carried out. The required drive can be a toothed gear drive, in which the number of teeth on the periphery of the further body differs from the number of teeth on the external shaft and thus a clear signal for a full rotation is available.

In summary, a host of advantages for the sensor arrangement of the invention with a concentric angle measurement on the shafts in particular through the placing of the magnetic central point and the sensor elements on the shaft axis result. With the two measurements of the respective magnetic field directions an error monitoring of the angle of the rotating component is possible, eg. a steering wheel on the basis of a comparison of both the magnetic field direction measurements.

Also used in vehicles the evaluation electronics can be modular-constructed in a compact housing, as a contact-free measurement of torque and steering wheel angle (>360°) is possible without additional friction torque. Thus an enclosed housing can be constructed, which is insensitive to moisture and makes possible a simple exchange of the sensor housing with the electronics.

The angle measurement, which can be carried out with the sensor arrangement of the invention can be carried out with a multiplicity of preferably contactless measurement procedures and is not limited to magnetic field direction measurement. The measurement can be carried out on many rotating components, eg. with an application in vehicles also on the steering gear in the passenger compartment, on the differential or on an engine shaft, for example to outputting the steering wheel angle, the wheel angle, the angular velocity, the angular acceleration and the torque.

These and other characteristics of preferred further developments of the invention are listed in the claims, the description and the drawings, whereby the individual characteristics are realised individually or in sub-combinations of the invention and in other areas and can represent advantageous and separate patentable designs, for which protection is claimed here.

Drawing

Embodiments of the sensor arrangement of the invention are described on the basis of the drawing. Shown are:

Figure 1 a section through a steering gear for a vehicle with a sensor arrangement for detecting torque acting on the rotating components and

Figure 2 a part sectional view of the front end of an internal and external shaft of the steering gear with an additional detection of full rotations of a steering column.

Description of the embodiment

In Figure 1 a steering gear 1 is shown in schematic view, which can be acted upon (torque entry) with a torque-effected steering movement. In the steering gear 1 is an external shaft 3, which features a torsional area 4 and a connecting piece 5 for a transferral of the rotational movement to a tie rod 6, whereby on this connecting piece the torque from the steering movement is further transferred with a corresponding gear (torque exit).

In the steering gear 1 there is, according to Figure 1, also an internal shaft 7, which is fixed to the connecting piece 2 (torque entry). On the front end of the internal shaft 7 is a magnet 8, in whose radial magnetic field a magnetic field sensitive sensor 9, for

example an AMR sensor, is arranged. In the front face bend of the external shaft 3 is a magnet, whose radial [original incomplete – translator] is detected by a second sensor 11.

The sensors 9 and 11 are connected to an electronic evaluation circuit 12, in which signals, dependent on the direction of the magnetic fields and thus on the rotation position of the sensors 9 and 11 can be detected and to some extent evaluated. There is no need to go into further detail here into the individual components and their functions in the evaluation circuit 12 for an understanding of the invention. The output signals of the evaluation circuit 12 are made available by means of an electric plug-socket connection 13 for connection to the motor vehicle electronics system.

In a steering movement carried out on the steering gear 1 according to Figure 1 a torsional angle (torsional angle of the external shaft) is produced by means of application of torque to the area of the external shaft 3, which lies on the connecting piece 2 (torque entry) and the area 5, which lies on the other front end (torque exit). The magnet 10 of the external shaft 3 is, then, rotated to the same extent as the area 5 of the external shaft on the so-called torque exit. The internal shaft 7 and the magnet 8 of the internal shaft 7 is, however, turned to the same extent as the area 2 of the external shaft 3 on the so-called torque input. Thus the two magnets 8 and 10 and their magnetic fields turn with respect to one another and the corresponding torsional angle can be detected. This angle of rotation of the magnetic fields on the place of the magnetic field measurement on the sensors 9 and 11 is proportional to the torsional angle to the angle of rotation of the external shaft 3 and thus to the torque.

In Figure 2 an extension of the steering gear 1 is shown according to Figure 1 with the additional drive of a rotating component 14. Over another toothed rim 15 on the front end of the external shaft 3 and over a corresponding toothed gear 15 on the additional component 14 a rotation of a third magnet 16 with it is effected, which can also be detected by means of a magnetic field sensitive sensor 17. The measurement principle and the evaluation thus preferably corresponds to the way the sensors 9 and 11 of Figure 1 work. With this arrangement it is possible according to Figure 2, by means of a different number of teeth of the two toothed rims 15, to carry out a clear

detection and counting of full rotations of the steering column connected to the connection piece 2.

Patent Claims

1. Sensor arrangement for detecting the rotational angle and/or the torque on rotating mechanical components (3,7;14), with
   - signal generating elements (8,10;16) and signal detection elements (9,11; 17), the signal generating elements (8,10;16) being secured to the moved mechanical components (3,7;14), characterised in that
   - on the rotating component a torsion shaft is formed as an external shaft (3), on the area (2) of which torque acts and in the area (5) of the front other end, the torque can be removed, an internal shaft (7) being arranged concentric to the external shaft (3), which is connected by its end to the external shaft (3) in the area (2) of the entry of the torque and that
   - on the front end of the external shaft (3) and the internal shaft (7) the signal generating elements (8, 10) are arranged, to which a fixed signal detection element (9,11;17) is allocated.

2 Sensor arrangement according to Claim 1, with
   - at least one magnet (8,10;16) as signal generating elements and at least one
   - sensor (9,11;17) as signal detection element (9,11;17), which emits an electric output signal dependent on the direction of the field lines of the magnet (8,10;16), characterised in that,
   - on the front end of the external shaft (3) and the internal shaft (7) the magnets (8, 10) are arranged with radially directed magnetic fields, to which one fixed magnetic field sensitive sensor (9,11;17), preferably on the shaft axis, is respectively allocated.

3. Sensor arrangement according to Claim 2, characterised in that

- the one magnet (8) on the internal shaft (7) for detecting the rotational angle of the area (2) at the entry of the torque a radial magnetic field is produced and the other magnet (10) is arranged on the external shaft (3) for detecting the rotational angle in the area (5) of the exit of the torque outside the first magnet (8) and a further radial magnetic field is generated and that
- under the influence of the torque the twisting of the magnetic fields can be measured relative to one another, the torsional angle being proportional to the torque.

4. Sensor arrangement according to one of the preceding claims, characterised in that
   - a drive (15) for a further rotating component (14) is positioned on the front end of the external shaft (3), with the rotations of the shaft (3, 7) being detectable greater than 360°.

5. Sensor arrangement according to Claim 4, characterised in that
   - the detection of the rotation of the further component (14) can also be undertaken with a magnetic field sensitive sensor device (16,17).

6. Sensor arrangement according to Claim 4 or 5, characterised in that
   - the drive is a toothed gear drive (15) in which the number of teeth on the rim of the further component (14) differs from the number of teeth on the external shaft (3).

7. Sensor arrangement according to one of the preceding claims, characterised in that
   - the sensors (9,11;17) are magnetoresistive sensors, which are arranged in the magnetic field of the magnets (8,10;16) in such a way that their magnetic field sensitive layer lies tangential to the rotating of the shafts (3,7;14) causing the change of angle.

8. Sensor arrangement according to Claim 7, characterised in that the sensors (9,10;17) are magnetoresistive AMR or GMR sensors, which emit a signal largely dependent on the field line direction of the magnets (8,10;16) connected to the rotatable shafts (3,7;14) and that

- in an evaluation circuit (12) from these signals the absolute rotational angle of the internal and external shafts (3,7) and from the relative torsional angle the acting torque can be determined.

9. Sensor arrangement according to one of the preceding claims, characterised in that
   - the internal and external shafts (3,7) are connected to the steering column of a vehicle.

10. Sensor arrangement according to one of the preceding claims, characterised in that
    - the internal and external shafts (3,7) are integrated in the axis of a motor.

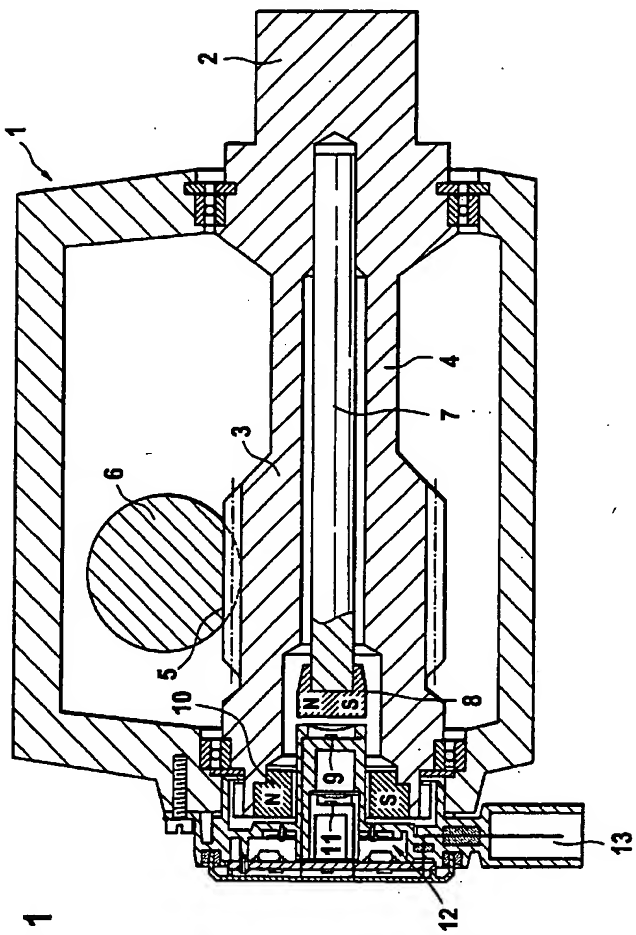

Fig. 1

Fig. 2